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ON THE ARTICLE OF S. VERNOV, N. DOBROTIN, AND G. ZATSEPIN "THE QUESTIONS OF THE EXISTENCE OF VARITRONS"

A. I. Alikhanyan

In the article of S. Vernov, N. Dobrotin and G. Zatsepin. This issue, page 1045, subsequently cited as A, number of results which we obtained in 1947-1950 have been presented in a form not conforming with reality.

Back in 1946 on first studying the composition of the soft component of cosmic rays by the method of magnetic analysis, we discovered that a noticeable portion of particles within the interval $1.8 - 5. 10^8$ e V/c, by their impulse and range cannot be classified as either protons or mesons (200 m_e). On the basis of this data we arrived at the conclusions that within the mass meson- proton interval there are present among the constituents of cosmic radiations other particles, and we proposed to name them "varitrons" [1, 2]. In 1947 on using higher power equipment we confirmed these basic results under conditions of more rigorous selection of particle trajectories and showed that the new particles observed extend far beyond the limits of the impulse spectrum region occupied by the μ -mesons (figure 2, [3]).

In subsequent investigations [4, 5] we have attempted to determine the value of the mass of the new particles from breaks in the deflection spectra. Such a method has led us to incorrect results, since on the one hand not all maxima in the deflection spectra were statistically sustained, and on the other a large number of individual mass values were not commensurate with the resolving power of our apparatus.

Article A analyzes essentially four of our investigations: (1) the work conducted using a small mass spectrometer [2], (2) that conducted using the large mass spectrometer [4], (3) A study carried out by the means of the same apparatus [5], and (4) that performed using a large electromagnet [6]. In none of these investigations, with the exception of [6], have we attempted to present quantitative correlations between different particle groups (proton, varitron, meson), since it was practically impossible to do this with any degree of accuracy, and we have always given merely the ratio of the total number of particles of the soft component to that of the hard. However from all these investigations it follows that beyond the impulse region corresponding to μ-mesons taking into account its maximum expanse, due to errors in measurements of impulses (Scattering within walls of the counters, geometrical dimensions of the counters, etc.) There were observed particles which could not be identified as either [redacted] μ-mesons or protons. According to the data derived from this entire work the number of such intermediate particles constituted about 0.5 percent of the hard component per 1 centimeter of lead absorber.

In their article S. Vernov, N. Dobrotin and G. Zatsepin (hereinafter cited as VDZ) attempt to determine the number of varitrons from the aforesaid work, but in so doing they perform a number of arbitrary operations which lead to erroneous results. First of all VDZ in determining the number of varitrons, terminate the spectrum at a mass value equal to 300 me. This arbitrary elimination from the spectrum of the most pronounced group of intermediate particles is completely unwarranted. Indeed, by definition we have designated as varitrons particles which, possessing impulses greater than $1.8 \cdot 10^8$ $^{eV}/_{c}$, are absorbed in filters of 5.4 centimeters Pb. We designated as varitrons those particles to which, by their impulse and range, must be attributed a mass greater than the mass of a μ-meson, and not that of a π-meson. At the time when we had first presented considerations relative to the existence of varitrons, no other particles except the proton and the meson having a mass of 200 m_e were known to exist. The fact that one year subsequent to our first investigations on varitrons the British physicist Powell discovered by another method tracks of particles heavier than the μ-mesons and named π-mesons, (The initial mass of a π-meson was estimated by Powell as being 400 m_e. Later on it was found to be equal to 270 electron mass.) does not entitle VDZ to exclude now, retrospectively, this group from our spectra. It is known that Powell having discovered the tracks of the new particles by different methods, established at the same time the most important properties of these particles. Nevertheless, first observations of particles heavier than μ- meson were made here, in the USSR, and this should not be ignored even after the fundamental work of Powell.

We wish to point out that even in 1948 VDZ repeatedly contended in the course of discussions that we cannot observe π -particles by means of our apparatus, since their life was estimated at 10^{-9} seconds. As is known now the life of π -mesons is $2.8 \cdot 10^{-8}$ seconds, and they are readily registered by our expanded equipment.

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§ 2. ON THE NUMBEROF PARTICLES WITHIN THE INTERVAL μ-MESON -- PROTON

In this paragraph we will show that the number of particles having a mass intermediate to that of a μ -meson and that of a proton, according to papers [2,3,5] actually fluctuates about the value of 0.5 percent on the basis of the hard component per 1 centimeter of lead absorber. Adverting to paper [2], VDZ, on page 1046, obtain for the entire interval of mass, those heavier than a proton as well as those included within the interval μ-meson - proton, a value of 3 percent of the hard component per 3 centimeters of lead absorber. In so doing they do not utilize the tables, which show the exact number of particles within each deflection interval, but effect the computation most roughly. Thus wishing to exclude from the entire spectrum of the soft component the region occupied by the protons they disect the interval of deflections 3 ÷ 5 centimeters (in [2] it is stated that one fifth of all the particles appertains to the deflection interval 3-5 centimeters); in so doing they make no allowance for the fact that in paper [2] it is further stated that: "Keeping in mind that the maximum error in the determination of deflections is equal to 1.25 centimeters, we may say that in the spectrum of positive particles the protons can cover the interval from 1.5 to 5 centimeters (Figure 22, a.b.)" [Here this figure is shown as Figure 1.]

Adverting to paper [2], the number of particles of mass greater that that of a μ -meson and smaller than that of a proton, can be found from Table 11 (page 330). In this table according to experiment 2az and 2 bz the number of positive and negative particles having undergone deflections of more than 5 centimeters, but less than 10 centimeters is equal to 36, and corrected for luminosity is 50. From Table 8 (on page 327 of the same paper) we find the number of penetrating particles, corrected for luminosity, to be 1700. Whence, taking into account the thickness of the absorber in experiments 2 az and 2bz we find that per 1 centimeter Pb the number of absorbed particles constitutes 0.8 percent and on subtraction of electrons, 0.6 percent. The amount of particles within the interval μ -meson -- proton, according to paper [3] is shown in Table 3 of paper [6] and constitutes $\sim$0.9 percent of the hard component per 2 centimeters Pb. If we wish to estimate quantitatively the number of particles appertaining to the interval μ -meson -- proton, we not only can but must take into account corrections for incorrect trajectories. These corrections are taken into account not immediately and in retrospect, as is stated by VDZ, but were pointed out in paper [2] (page 692) wherein the percentage of such incorrect trajectories was determined. For this reason those improvements which are described in papers [3,5] were made and it is precisely by means of them that we have succeeded in separating the most dependable trajectories.

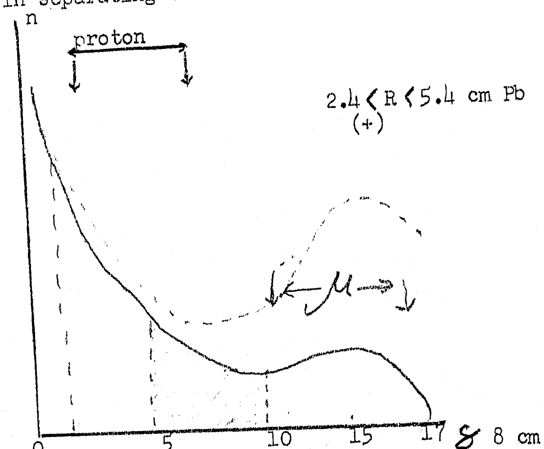

Figure 1. Spectrum of deflections of positive particles. Dotted line - corrected for luminosity, solid line- not corrected for luminosity.

Spectra of the soft component presented in this paper [3], and obtained in 1947 by means of a large permanent magnet are shown in the VDZ article, as Figures 5 and 6. Considering these spectra, VDZ point out that we did not have sufficient reasons for plotting the curves from experimental data but should have drawn a smooth curve as [redacted] is done in Figures 5 and 6. We do not controvert the fact that many of the maxima shown in Figure 5 and 6 do not constitute a convincing proof of the existence of particles of that specific mass; nevertheless from these spectra it can be seen that within the interval μ -meson -- proton, there are present particles which cannot be induced by mesons and still less by protons (Figure 2). Already in the work [3] several precautions were taken to protect the apparatus from parasitic phenomena, and on careful control of the trajectories we still found that a considerable humber of trajectories are [redacted] due to new particles and not to parasitic background.

Taking under consideration paper [5] which is dealt with in a most detailed manner by VDZ, we may first of all propound the question: Why did VDZ find it necessary to use, in effecting quantitative computations, the figures shown in Table 4 and 5 of paper [5], when it is stated in the same paper that this table includes without exceptions all those particles which produced a single discharge in the system of coordinate rows? Moreover it is also stated there that we were not in a position to exclude particles which had grazed the polar counters, and particles which did not reach their rating counter of row IV, and in the same paper, two pages later. there is shown a spectrum plotted by "correct" trajectories (The term "correct" as applied to these particles is taken from paper [5], that is by trajectories which had reached their rated counter of row IV. Use of all trajectories of particles without selection is well known to distort the result, which should be apparent to any experimentator. Also VDZ limit themselves, the same as with paper [3], (completely unjustifiably) to values of mass exceeding 300 me and in addition establish completely arbitrary limits for this or that group of particles.

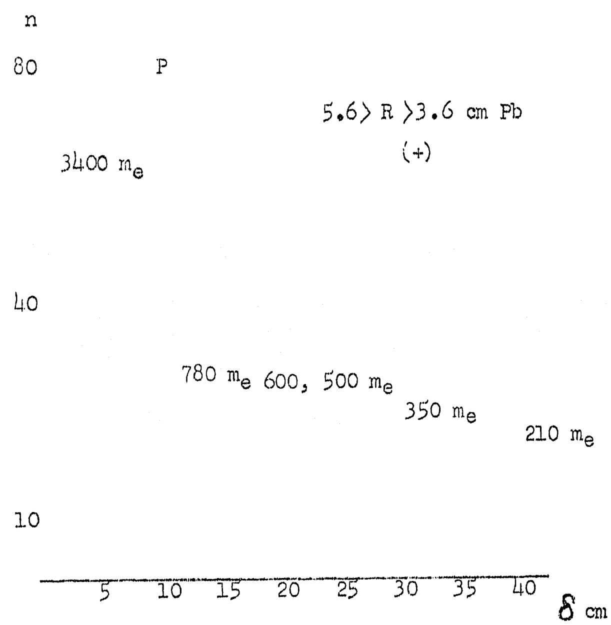

Figure 2. Spectrum of deflection of positive particles, not corrected for luminosity.

As in papers [2] and [3], in order to evaluate correctly the number of particles within the interval μ - meson -- proton, we must determine first of all, up to what minimum deflection the μ - meson may extend and what maximum deflection is attained by protons within the given range interval. In determining these limits a number of factors must be taken into account, which determine the magnitude of deflection; these factors are: thickness of filters, true path of the particle within the filter [5a], taking into account the angle of incidence of particle with the filter and the inaccuracies of impulse (deflection) determination as a result of scattering within the counter walls and of terminal dimensions of the counters. One of the most important factors which determine the value $\Delta \delta$ is the scattering within counter walls. VDZ, however, on compiling the table merely took into account the geometric dimensions of the counters, that is, the very smallest error, and thus obtained incorrect correlations between the number of particles within the groups.

In paper [5] there is given the constant of the instrument, which is equal to $6 \cdot 10$ eV/c; derived from the break of the proton maximum. In the preceding paper the constant $5.2 \cdot 10^9$ eV/c was used which was derived from the value of the magnetic field. In earlier work we were not concerned with quantitative correlations and therefore a more accurate determination of this value did not appear to be indispensible. Subsequent repeated measurements of the magnetic field and topography also yield the figure $5.2 \cdot 10^9$ eV/c; we had deemed it most circumspect to adopt the average of these two measurements obtained by means of independent methods and equal to $5.6 \cdot 10^9$ eV/c.

Let us now consider up to what deflection the μ - mesons can extend within this spectrum. First, let us determine what was the actual range of μ - mesons and π - mesons registered in the course of the 1948 experiments. (paper [5]). As was

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pointed out in [5] the apparatus did not register particles having impulses of less than $1.6 \cdot 10^8$ eV/c. This signifies that μ - mesons with a range of less than 4 centimeters Pb, were practically blown off. It should be noted that particles with impulses of the order of $1.6 - 1.8 \cdot 10^8$ eV/c, pass through the depth of the absorber 1.2 - 1.3 times greater than on vertical passage. Consequently the range of π - and μ - mesons according to this work, is within the limits of 3.0-4.5 centimeters Pb, and, taking into account path elongation within a lead filter due to scattering, is within the limits of 3.3 - 4.9 centimeters Pb, the mean range being 4.1 centimeters Pb. Correspondingly, with this mean range the mean deflection for a μ - meson is equal to 36 centimeters, and for a π - meson 29.5 centimeters. Calculations show a standard error $\Delta \delta$ = 3.5 centimeters. It can be determined on knowing the thickness of second row counters, the geometric dimensions of the counters and dispersion of impulses, connected with range fluctuations. Figure 3 shows Gaussian distribution for π -particles and tail distribution of π- mesons. As can be seen from Figure 3 reasonable limits of μ - mesons correspond to δ = 23 centimeters, and for the π - mesons to δ = 31-32 centimeters. From figure 3 it is possible to estimate approximately the number of particles appertaining to the region μ -meson -- proton; it is equal to 406. Adding 445 negative particles we obtain for this interval 850/100,000, that is 0.85 percent and subtracting 20 percent of unidentified electrons, 0.68 percent for a range interval of 1.2-1.6 centimeters; consequently for 1 centimeter there will be $\sim$0.5 percent.

[See Figure 3 on following page]

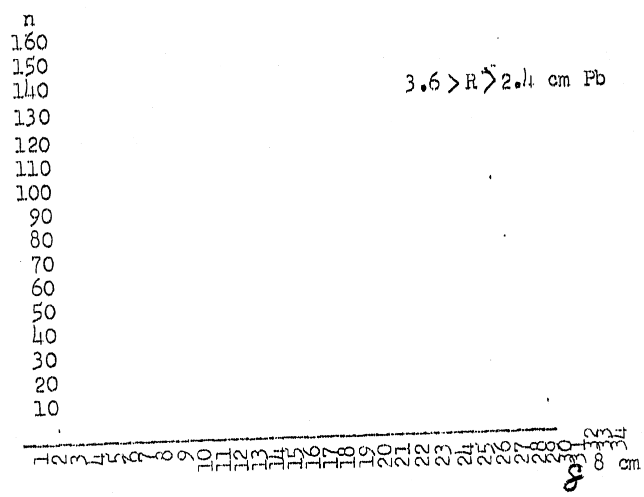

Figure 3. Spectrum of positive particles having reached the rated counter of row IV (re-computed for luminosity)

From the aforesaid it is apparent that year after year we had observed a phenomenon to which from the very beginning was ascribed a correct explanation. This physical phenomenon and not "parasitic background" as state VDZ, is due to new particles and primarily to particles having a mass of 300 m_e.

If one determines the number of varitrons, that is, the number of particles appertaining to the interval μ- meson -- proton, from the published data, it is apparent from the adduced calculations that this number will constitute about 0.4 - 0.5 percent of the hard component per 1 centimeter of lead absorber within the investigated gamut of ranges. This data is summarized in Table 1, wherein are shown also the results given in paper [6].

It is apparent therefrom that the assertion of VDZ relative to the high percentage of varitrons observed in the course of different investigations, and the wide fluctuations of this number do not conform with reality.

[See Table 1 on following page]

§ 3. CONCERNING THE BACKGROUND

In the 1948 paper [5], as in prior ones, we derived the distribution of false absorbtions from deflections (In paper [3] the background distribution curve is not given, and only the integral value of background is shown, which is equal to 0.75 percent of the hard component). From data thus obtained it is apparent that for 10,000 penetrating particles which pass through the apparatus within the interval of 16-30 centimeters, not a single instance of false absorbtion was observed among particles which satisfy the selection from row IV. Conversely practically all instances of false absorbtion are concentrated in the region of 0-8 centimeters deflections. In the case of negative particles they constitute ~ 90 percent of the effect observed within this deflection interval. On the basis of this data and also of ionization measurements as early as 1948 we had excluded from Table 8 of paper [5] the negative particles to which we had attributed masses greater than that of a proton. The positive particles were retained (they are shown in Table 8 of paper [5]). In the 1949 paper [6] and also in 1950 work the positive particles corresponding to mass values greater than a proton are found to be present in an appreciable number and constitute and appreciable proportion of the number of protons. The nature

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TABLE I

NUMBER OF PARTICLES WITHIN INTERVAL MESON - PROTON ACCORDING TO DIFFERENT PAPERS

Paper No	Deflection interval	Range in cm	Basic number of particles	Number of correct trajectories	Number of particles corrected	Number of protons	Number of hard particles	% with respect to hard component per 1 cm	% with respect to hard component on subtractions of electrons	% with respect to protons on subtraction of electrons
[2] table 11	10-5 cm	2.4-6.4	36	-	50	39	1700	0.8	0.6	125
[3] table 36	27-11 cm	-	371	278	430	400	40,000	0.55	0.45	80
[5] figure 8	31-16 cm	3.3-1.9	-	-	840	630	100,00	0.60	0.4	100
Present article Figure 2 [6] Table 4	1840-230 m_g	16-24	-	101	234	300	40,000	0.3	0.3	75

of these particles is being studied by us in detail. Apparently a considerable part of them are nuclei of light elements. However in the article of VDZ on page 1056 it is stated: "In addition in the new spectrum particles heavier than protons have completely disappeared ... etc. Thus the 1950 work of Alikhanyan and Alikhanov fully shows the erroneousness of their work published in 1947, 1948 and 1949 in which, as is now fully apparent, the background had a noticeable effect". I believe that in this instance another conclusion must naturally occur, namely: superficial knowledge on the part of VDZ of experimental data and hasty conclusions. One may ask on what basis have VDZ decided that particles corresponding to masses greater than the mass of a proton, have completely disappeared, when in [6] and also in the course of a number of discussions we had pointed out that positive particles are present in this region of the spectrum, just like they were present in earlier investigations, and constitute an appreciable portion of the number of protons. Comparing this interesting region of the spectrum to a "parasitic background" the authors have declared the work of 1947-1949 erroneous. Further on page 1056 VDZ state that "up to 1950 the mass spectrometer registered essentially the background", that is in the opinion of VDZ we had not even observed mesons and protons. There is no need to point out how unfounded and incorrect is this assertion. This characteristic of VDZ's criticism that in their computations they painstakingly by-pass the region occupied by the π-mesons, while they expand to the entire mass spectrum the conclusion which they derive on the basis of the region π- meson- proton. Citing the completely unsupported figure of 80 percent for background within the interval π-meson -- proton (excluding π- meson), VDZ state "under such conditions there was no justification for announcing the discovery of new particles having different mass values or even one mass value or even one mass value different from the mass values of a meson and a proton". In expressing such decisive assertions VDZ should prove that within the region occupied by the π-mesons the background constitutes any appreciable portion of the number of π- mesons. At the same time the number of π- particles within the observed impulse region exceeds the background many times and consequently the cited quotation from publication A is completely erroneous.

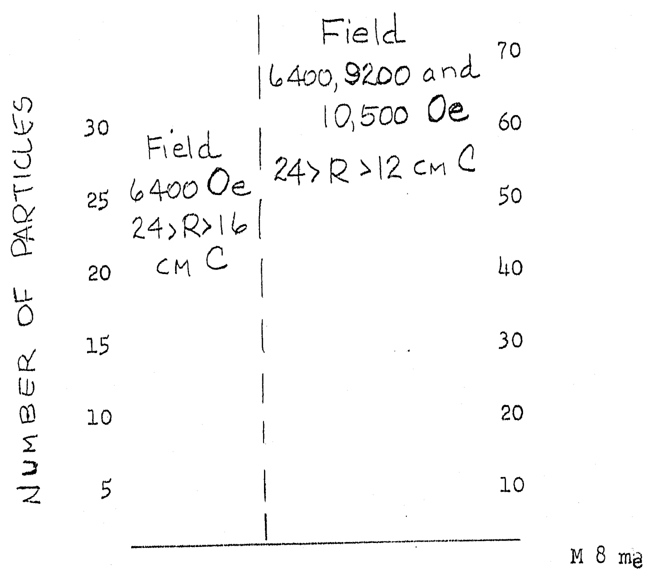

Figure 4. Mass spectrum according to 1950 work not corrected for luminosity shaded [area] corresponds to negative particles

§ ROUGH ESTIMATE OF THE NUMBER OF PARTICLES WITHIN THE INTERVAL π MESON--Proton.

In paper [6] it is stated that determination of the number of particles appertaining to the zone π - meson -- proton, can be made very roughly according to paper [3], primarily because this region has not been spectrally isolated. In determining the number of particles appertaining to the region π - meson - proton as well as to the region μ - meson - proton, we took into account only those trajectories which satisfied the criterion of trajectory selection in accordance with experimental conditions which obtained in the work referred to. The deflection interval pertaining to the region π - meson - proton, is correctly stated in paper [6] as being from $\delta = 11$ to $\delta = 21$ centimeters, taking into account the actual errors of measurements. The limit proposed by VDZ for π - particles, $\delta = 23$ centimeters, corresponds to an "ideal" case not taking into account the actual amplification. Thereby the number of particles pertaining to this region constitute $\sim$ 0.35 of the number of protons. We wish to recall that these values relate to experimental conditions different from those of 1950.

Analogous estimates can be made on the basis of the 1948 work, but it is still necessary to establish correctly the limits of π -meson and proton regions, taking into account the actual experimental conditions. Moreover it is necessary to select from the observed trajectories those which according to paper [5] do not arouse any doubts. Therefore, it is necessary to make use of Figure 3, of the present article (Figure 3 corresponds to the spectrum shown in Figure 8 of paper [5] converted for luminosity) plotted by trajectories which had reached their rated counter of row IV. According to this spectrum the number of particles within the interval π- meson - proton, is found to be $\sim$ 0.45. Both values, obtained from an unresolved spectrum, differ from that observed in the 1950 experiments approximately 2-3-fold (In Table 4, VDZ show the figure 0.85 for the intermediate particles, which figure is obtained allegedly according to computations of Alikhanov and Alikhanyan. Actually, in paper [6] there is shown the figure 0.35. By attributing to us erroneous computations VDZ mislead the reader.) This difference is possibly due to the different physical conditions of the experiments.

The position taken by VDZ is contradictory, to say the least. Indeed on the one hand these authors assert that in our earlier experiments there are present many extraneous particles, while on the other they persistently seek in the course of calculations to include more doubtful trajectories and object to selection of trajectories according to the experimental possibilities of the apparatus. Such a selection is made not only by us but by all those who are concerned with similar problems.

From the aforesaid it is apparent that in the calculation of the number of particles appertaining to the region π - meson - proton, VDZ commit two errors: (1) they make use of the total number of particles which have passed through the assembly without segregation of false trajectories and of trajectories caused by electrons; (2) not taking into account the measurement errors they include thereby, within the group π meson - proton, a large number of protons and π -particles, and decrease the number of protons.

As a result VDZ obtain incorrect figures and reach incorrect conclusions.

§ TRACKS OF VARITRONS ON PHOTOGRAPHIC PLATES.

In § 3 of their article VDZ report that the same photographic plates, by means of which we had detected tracks of varitrons, and which were made available to them for duplicate measurements, were studied in detail at the laboratory of FIAN. In this it was found that "Alikhanyan, Samoilovid et al., grossly overestimated the accuracy of mass determination of particles by the method of grain counting". I cannot agree with this assertion, since the photographic plates referred to were studied and measured by various associates at different laboratories. Hence in my opinion a mere assertion is not sufficient in this instance. As I see it the most natural thing would be to report what results were obtained from counting the grams for each individual particle trajectory of our plates. If this were done a real possibility would be provided of comparing results and one could ascertain what is the accuracy attained in counting the grains by associates of FIAN who have studied our plates. The authors state that according to paper [7] there were observed 63.5 percent of intermediate particles with respect to the number of protons recorded. In the paper cited we did not show such figures, and did not cite at all the content, in percent, of any particles. If VDZ are using the number of protons shown in the graphs of Figures 1 and 2 of paper [7], this is to no purpose because the graphs included only duplicate measurements of protons utilized in calibration. (In the determination of the

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number of intermediate particles one should be limited to trajectories with large residual range, inasmuch as they can be better separated from protons.). Moreover in paper [7] on page 666 it is stated: " It must be noted that the majority of tracks, recorded on the photographic plates, are those of protons".

Referring to investigations abroad, VDZ mention paper [8] involving different physical conditions, and are silent as to other papers [9-11], in which there were also found tracks of particles heavier than 300 m_e, although one to two years later the same was done in our investigations. Incidentally in our paper there was reported for the first time the emission from a star of a particle having a mass greater than the π- mesons, and only subsequently such instances were detected in [11] and others.

§ 6. THE CONCLUSIONS REACHED BY S. VERNOV, N. DOBROTIN AND G. ZATSEPIN FROM PAPER [12]

VDZ make repeated references to results of their numerous investigations concerning the measurement of mass of cosmic particles. At the same time they cite but a single note recently published in the DAN SSSR [12]. Let us consider what experimental material has been presented in this paper. We note first of all that the paper does not show a diagram of the experimental unit, so that it is impossible to determine which contentions of the authors are unquestionable and which are debatable. From [12] it follows that the authors have recorded in a field of 4400 O_e, 24 particles within the impulse interval $1.5 - 6.6 \cdot 10^8$ eV/c, of which 23 were found to be protons. However the paper does not show the basic experimental result — the distribution of these 23 particles by mass, on the basis of which one could form an opinion as to the measurement accuracy within this field. There is no need to prove that with such insignificant statistical material, there can be no question of reaching any kind of sober conclusions relative to new particles, since the observed known particles (protons) are clearly insufficient in number. However if an attempt is made to arrive at some conclusions on the basis of this statistical material, one ought to know what is the registration efficacy of the particles sought for within the assigned range interval wherein the protons are registered.

In [12] there is not given the dependence of registration efficacy of particles of given mass upon the impulse or range of the particle, and therefore it is impossible to verify the correctness of the authors' basic contentions. The authors give the average percentage of "blowing off" of particles with a mass of 500 m_e, without supporting this value by calculation data. From the paper it follows that the authors observed 23 protons with a range 0-4 centimeters Pb, but within this range interval particles with a mass 500 m_e (with which the article is concerned) must be fully "blown off". Indeed the maximum impulse of particles having a mass of 500 m_e within the range 0-4 centimeters Pb is equal to $2.5 \cdot 10^8$ eV/c, but the π- mesons have the same impulses within ranges of 7 - 9 centimeters Pb.

It is further stated in [12] that μ and π - mesons are practically completely "blown off", and consequently particles with a mass of 500 m_e, even if they constitute 50-100 percent with respect to the number of protons within the interval 0-4 centimeters Pb would practically also be "blown off" and could not have been observed.

Still fewer conclusions can be drawn from experiements conducted in a field of 6900 and 9200 Oe, even though the article states that the percentage of "blow off" of particles with a mass of 700 m_e is equal to 40. But these two values of the field differ from each other by 1.33 times, with the relative duration of the observation in the case of either field value being unknown to the reader! Therefore it is not known what the figure 40 percent refers to.

Finally, the authors state that the mass of the particles was determined only for trajectories which were not accompanied by the occurence of secondary particles. The question then arises, how do the authors know the behavior of the particles following their stopping within the filter? Unstable positive particles will be necessarily accompanied by secondary products, while the negative on entrapment by nuclei also form secondary particles. It would be interesting to know what the authors would have found on attempting to observe π- particles by means of this criterion? As I see it, first it is necessary for the authors to attain conditions of observation under which one could actually observe, experimentally, well-known particles, namely, μ- mesons and protons. Only after spectra containing protons and also μ mesons have been obtained is it possible to verify the correctness of the performance of the assembly and that of the calculations and only thereafter having accumulated sufficient statistical material can conclusions be drawn as to the existence of new particles and, even more so, concerning their relative number.

§ 7. OUR 1950 WORK

In the article of VDZ there are several erroneous assertions concerning our 1950 experiments. Let us consider the more important ones:

(a) In §5, VDZ devote much attention to false absorptions and voice the suspicion that in the 1950 apparatus false absorption responses could have had a noticeable part. I aver that in the 1950 apparatus false absorption responses had practically no part whatever. False absorption signifies lapses of counters and other apparatus irregularities that simulate the stopping of particles. The number of such false stops (more precisely their upper limit) was determined continuously, as the measurement of the basic effect took place, in the following manner. The number of stoppings of negative particles having impulses from $0.5 \cdot 10^9$ to $1.8 \cdot 10^9$ eV/c was determined. In one series of measurements it was found that for 30,000 penetrating negative particles of impulse within the limits of $0.5 - 1.8 \cdot 10^9$ eV/c, there are observed only 3 stoppings of negative particles with impulses within the same limits. Let us assume that these instances are false absorption responses. From this we can determine the number of false stoppings within the interval under consideration namely $2.8 - 4.8 \cdot 10^8$ eV/c. From the spectrum of hard particles it is known that for 30,000 particles within the above indicated interval there are about 3000 penetrating particles having impulses of $2.8-4.8 \cdot 10^8$ eV/c. Consequently the upper limit of the number of false absorption responses within the limits under consideration will be 0.3 or one case per 100,000 penetrating. The measured effect constitutes about 1 per

1000 penetrating particles.

(b) On page 1058 VDZ consider the scattering of particles within counter walls in the 1950 experiments [6] and - once more draw erroneous conclusions. They consider that isolated instances of scattering over an angle greater than the probable angle of multiple scattering are capable of producing the occurence of a noticeable number of intermediate particles. Using the results of our experiment conducted in a field of 200 G (on observed case of deflection over four counters) they arrive at the conclusion that due to scattering of protons there may occur intermediate particles with a mass of 1200 m_e in amounts of 2 percent on the basis of the number of protons. Let us point out first of all that by means of such a mechanism the authors will be unable to produce a single intermediate particle of negative sign. Moreover in determining such an effect the authors make a two fold error, since isolated instances of scattering over relatively large angles will equally decrease and increase the curvature radius and consequently even according to the computations of VDZ only 1 percent of the positive particles, on the basis of the number of protons, can simulate a mass 1300 m_e of positive sign. Actually these intermediate particles correspond to a mass of 600-1000 m_e and not of 1200 m_e and for this reason alone the calculated percentage must be reduced by several times. Not satisfied by such a small percentage of simulated intermediate particles (greatly exaggerated as shown before) the authors draw upon the mesons for an explanation. In other words the authors assume that trajectories of intermediate particles can occur as a result of scattering of mesons within the walls of the counters. As can be readily ascertained this requires scattering to occur over $\sim 10^{\circ}$, which in the experiment without a magnetic field corresponds to a deflection over 20 counters! Naturally such a trajectory ceases to satisfy the circumference, a fact that VDZ can readily verify.

From the foregoing it follows that the remarks of VDZ concerning the part played by scattering in the 1950 experiments are of no practical interest.

(c) On page 1058, under "a", VDZ "refute" an important fact noted by us in [6].

From the experiment it follows that all negative particles beyond the meson 300 m_e, absorbed in the filters have impulses comprised within the narrow interval 3-$4.5 \cdot 10^8$ eV/c. Within the adjoining interval ($4.5 - 6.0 \cdot 10^8$ eV/c) only one tenth of their number is observed. This fact indicates, from our standpoint, that the intermediate group of particles is absorbed within the filters mainly as a result of ionization losses of energy.

Emphatically controverting this view VDZ resort to the spectrum $dE/E^{1.5}$ and find that within the interval $4.5 - 6.0 \cdot 10^8$ eV/c there must be observed five negative particles, which is indistinguishable from the three actually observed experimentally. This entire computation is a gross error. If the data shown in [6] is used correctly and the number of negative particles is calculated on the basis of the spectrum $dE/E^{1.5}$ the expected number is found to be 20 and not 5, - that observed being 3. Such a sharp decrease of the number of retained particles on slight alteration of the impulse apparently cannot be explained by means of the spectrum, which was also stated in paper [6], and is an argument in favor of the ionization mechanism of the breaking of particles within the filters.

(d) In § 5, VDZ attempt to prove that nuclear absorption of π particles can fully explain the occurrence of intermediate particles. Assuming that the π meson spectrum is of the form $dE/E^{1.5}$ (which by no means can be considered as established) they find that there have passed through the apparatus 400 $\pi-$ particles with impulses of $3 - 4.5 \cdot 10^8$ eV/e. A further assumption is made (reference being MADE to paper [13]) that interaction Section IS equal to the geometrical section of the carbon nucleus. On this basis VDZ obtain 80 instances of expected stopping of $\pi-$ particles, which is in excess of the 45 intermediate particles observed during the same period. This entire calculation is without basis.

1. The spectrum of π-mesons under a block of lead at an altitude of 3200 meters is not known. The use by VDZ of data [13] obtained at very high altitudes is unwarranted.

2. For a computation of nuclear stoppings of π mesons it is necessary to know what portion of the section of interaction of $\pi-$ mesons leads to hazardous instances of complete stopping and large loss of energy of $\pi-$ particles. VDZ assume that all instances of nuclear interaction of $\pi-$particles are hazardous (strong deflection of a particle due to scattering within the filters is detectable in most instances in the 1950 apparatus) and by so doing magnify by several times the hazardous effect. Quantitative data for interaction Sections of $\pi-$ mesons with impulses $3-4.5\ 10^8$ eV/c (190-330 MeV) are not available in the literature, therefore direct measurements of ionization capacity of intermediate particles is the

best means of finding out as a result of what processes stopping of particles takes place.

In the following paragraph are shown results of the corresponding measurements carried out for a second time in 1951.

8. DIRECT MEASUREMENTS OF THE IONIZATION CAPACITY OF INTERMEDIATE PARTICLES

In [6] we have shown a number of facts which indicate that the absorption of most particles of the intermediate group is caused essentially by ionization. One important fact as pointed out in [6] is the systematic impulse increase of retained particles depending upon increase of thickness of the filter within which the particles have been retained. This important fact is explained by VDZ without any foundation, as due to errors in the interpretation of results. We wish to point out that we have repeatedly proposed to the associates of the FIAN laboratory to interpret results obtained by us, which they should have done before expressing such unfounded assertions. Here we will briefly give the results of direct experiments. These measurements were conducted by V. Kharitonov and G. Marikyan in which concurrently with measurement of impulse and range of an individual particle was also determined the ionization produced by it within the gas of a proportional counter (methane 30 centimeters + argon 10 centimeters). The latter had the shape of a rectangular box and was placed between rows V and Vl of the unit (Figure 10, paper [6]. Impulses generated within the proportional counter, were linearly intensified and the magnitude of outgoing impulse was determined by means of 24 discriminators.

Table 2 shows data on mean ionization capacity of protons and mesons with different residual ranges. Table 3 shows the results of measurements of the ionization capacity of intermediate particles. There were observed 13 particles with impulses $1.9-4.2 \cdot 10^8$ eV/c and a residual range less than 1.8 centimeters Pb and 21 particles with a range $6 > R > 3$ centimeters Pb .

From Table 3 it can be seen that of the 13 particles with a small residual range, 10 particles possess ionization capacity, exceeding the minimum 2.0 - 3.5 times. Mean ionization capacity of all 13 particles of this group is greater than 2.7. Table 4 shows results for particles having a residual range from 3 to 6 centimeters Pb . Here also a considerable majority of the particles have [redacted] an ionization capacity exceeding the minimum 1.5-3 times. Mean ionization capacity of all 21 particles of this group is equal to $\sim$ 1.9.

From the data shown it follows directly that intermediate particles cannot be identified with π mesons, since the latter having impulses of $3-4.5 \cdot 10^8$ eV/c must ionize the gas like relativistic particles. It cannot also be assumed that trajectories of intermediate particles are caused by electrons. This is especially apparent from measurements of ionization produced by particles with a small residual range.

[See next pages for Tables 2, 3 and 4]

Mean impulse of 21 particles is equal to $3.40 \cdot 10^8$ eV/c and mean ionization $\sim$ 1.9. Therefrom we have an average mass equal to $740 \pm 75\ m_e$. One can also determine the average mass from the mean value of range and ionization. In so doing we have $840 \pm 200\ m_e$. Finally average value of the mass determined from range and impulse

TABLE 2

Nature of Particles	Residual range in cm.		Relative ionization capacity			
			Rated	Experimental	Errors	
	from	to			Statistical	Graduation
Protons	1.5	2.5	3.4	2.8	0.11	0.06
Ditto	2.5	3.5	2.7	2.35	0.08	0.05
Ditto	3.5	4.5	2.2	2.0	0.10	0.05
Mesons	3	4.5	1.2	1.14	0.06	0.03
Penetrating	14	-	1.0	-	-	0.03

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TABLE 3

MAXIMUM RESIDUAL RANGE R < 1.6 CM Pb

No. of film	p. 10^{-8} eV/e	M from range and impulse	Relative ionization capacity	No of film	p.10^{-8}e/Ve	M from range and impulse	Relative ionization capacity
325	- 3.65	-1100	> 3.6	457	- 4.30	- 1400	0.8
338	- 3.27	-940	2.3	468	2.73	720	1.6
338	2.8	-800	2.2	517	3.09	880	> 3.7
351	3.50	1100	> 3.7	586	- 2.0	- 520	3.1
357	1.93	500	> 3.6	612	- 3.03	- 900	> 3.6
396	3.13	900	3.1	545	- 2.3	- 570	1.8
431	- 3.94	-1280	1.6				

TABLE 4

No. of film	p. 10^{-8} eV/c	Mean range in cm.	M from range and impulse	Relative ionization capacity	No. of film	p.10^{-8} eV/c	Mean range in cm.	M from range and impulse	Relative ionization capacity
328	2.84	3.78	620	1.17	423	- 3.27	5.90	- 585	1.44
333	-3.94	4.56	-920	1.72	425	- 3.06	5.36	- 565	3.04
335	4.50	4.67	1090	2.32	426	- 3.38	6.18	- 600	< 0.47
343	3.00	3.82	655	1.70	460	4.30	5.64	930	3.14
347	-3.16	4.60	-640	1.82	486	3.27	4.97	650	2.72
375	2.91	3.82	640	> 3.7	527	- 3.19	4.96	- 620	0.78
422	3.60	3.80	880	0.63	574	- 3.60	4.80	- 760	1.23
446	3.38	4.80	700	1.40	574	3.78	4.25	850	1.80
474	2.71	3.95	560	2.83	583	- 3.42	4.3	- 900	2.0
356	2.97	5.30	540	1.13	588	- 3.24	3.0	- 900	3.2
410	4.30	5.70	930	2.57					

is found to be equal to 740 me.

Measurements of the ionization capacity of intermediate particles together with measurement of the impulse of these particles makes it possible to effect an independent, separate determination of the mass. When doing this it is found that the mass of these particles is greater than the mass of a π meson but is smaller than the mass of a proton.

It is of interest to note that lately there have appeared in the literature a continuously increasing number of communications in which the authors find particles heavier than the π-meson. Recently a paper was published [14] in which more than 10 particles were observed having masses $\sim$ 600 - 1200 me, according to the authors' estimates. At the same time life of these particles based on a rough estimate by the same authors is found to be $\sim 10^{-9}$ seconds, or still greater than this value. The same estimate of life duration was given also in paper [15] the authors of which observed three trajectories of particles with a mass $\sim$ 600 - 1000 me. The so-called charged V-particles observed by various investigators are possibly the same intermediate particles which we had observed and are now observing. Estimate of life duration of these particles ($\sim 10^{-10}$ seconds) cannot be considered as being accurate. On the contrary, since apparently these same particles are being observed also as having low velocities, it must be assumed that their life is 10^{-9} seconds or even in excess of this value.

I believe that VDZ in insisting that life of intermediate particles must be 10^{-10} seconds are no more correct than when they insisted that it is impossible to register π- particle by means of our expanded equipment because of the short life of π- mesons.

ON THE CONCLUSIONS OF VDZ (PAPER A)

Concerning point 1. Under point 1 in their conclusions VDZ on the basis of an incorrect number of varitrons (see § 2 and 4) make a comparison of earlier work with that of 1950. In so doing they reach the conclusion that the 1950 work completely cancels all previous results (see page 1060). This deduction of VDZ is completely erroneous. As we have already pointed out in § 2 the number of varitrons within the interval μ meson - proton constitutes 0.5 - 0.3 percent of the hard component per 1 centimeter Pb in all communications [2-4, 6]. Within the interval π-meson - proton there is observed an about 2-3 fold difference, which possibly is due to different physical conditions of the experiment. Moreover VDZ on considering the region π-meson - proton expand without any foundation, their (incorrect) conclusions to include the region of the mass spectrum occupied by π-particles wherein the effect exceeds the background many times.

Concerning point 2. Of the "numerous" investigations of VDZ relating to the problem under consideration, I am aware of only a single note in DAN SSSR. From this publication no data can be derived which would indicate the presence of "parasitic" effects in our experiments, and still less would permit their estimation in our measurements.

Concerning point 3. The uncertainty inherent in many of the maxima has been mentioned in [6] as well as in the present article. One should not, however, confuse the fictitiousness of this or that maximum with the very existence of the particles within the given region. We may recall that in paper [4] on page 691 we stated that "even if the curves did not display pronounced maxima, we still would have to assume a great variety of masses".

Concerning point 4. From the work of N. Dobrotin et al., on the study of ionization spectra [16, 17] no data can be derived relative to the mass of cosmic radiation particles. A detailed discussion of this work will be presented in a separate article.

Concerning point 5. In connection with the effects which lead to the occurrence of particles heavier than the $\pi-$ meson, the analysis by VDZ comprises a number of erroneous calculations, which I have pointed out in § 7, and which arose probably as a result of a superficial knowledge of the 1950 work. Moreover in their computation of the different effects (scattering, nuclear absorption, etc.) VDZ exaggerate to a considerable extent the part played by these effects. Therefore the conclusions stated by VDZ under 5 are completely unfounded.

CONCLUSION

In 1946 we discovered that certain particles of cosmic radiation possessing great impulses are stopped within filters of a thickness of only several centimeters of lead. This phenomenon could not be explained on the basis of the then known $\mu-$ mesons. We deduced that in cosmic rays there are present other particles, heavier than $\mu-$ meson, and named varitrons. In 1947 we confirmed this phenomenon, and on the basis of the ionization mechanism of particle absorption we gave tentative data relative to the mass of these particles, from the more pronounced breaks.

[See Table 5 on next page]

Continuing these investigations late in 1947 and in 1948 and having conducted a number of controlled experiments we had

TABLE 5 [3]

3.6 > R > 1.2 Cm. Pb		5.6 > R > 8.6 Cm. Pb		Masses most definitely established
+	−	+	−	
		180	200	
200	200	200	260	± 200
350	350	350	350	± 350
500	500	600	500	± 500 - 600
-	950	-	950	- 950
2000 (1840)	-	2000 (1840)	-	+ 2000
3400	-	3400	3400	+ 3400
8000	-	8000	-	+ 8000
-	-	-	2000	- 20000

accumulated extensive statistical material and made an attempt to generalize the mass spectrum. However in so doing we overestimated the resolving capacity of the instrument and utilizing individual breaks within different spectra, which were frequently statistically unfounded, we obtained a whole series of individual mass values, shown in Table 3, of paper [4], also included in the VDZ article. The method used was found to be incorrect, and thereafter we discarded it. In addition in 1948 it was shown that trajectories of negative particles to which we had attributed a mass greater than that of proton, are almost entirely due to extraneous causes and hence in Table 8 of paper [5] they were not included. At the same time the positive particles within the same region of mass remained approximately in an unchanged number but their nature still remains unknown. After further improvement of method we gradually attained that embodied in the 1950 unit. Spectra obtained on progressive improvement of the apparatus are shown in Figures 1, 2 and 3. From the more nearly perfect spectrum obtained in 1950 it can be seen (Figure 4) that together with a distinct [redacted] maximum of μ mesons there is present a second corresponding to a mass $\sim$ 280 - 300 me, which in earlier work was not separated from the first but occupied a region of the spectrum extending far beyond the limits of that region into which μ- mesons still penetrated.

In the μ meson - proton interval there are observed two more groups of particles to which can be attributed, from their impulse and range, a mass of 500 - 1000 me. In addition there is observed in the 1950 spectrum, as was true previously, an appreciable number of positive particles corresponding to a mass greater than that of a proton; the nature of these particles is being investigated.

In the 1950 apparatus the ionization capacity of the particles was determined, and it was shown that the majority of particles constituting the group 500 - 1000 me, display an appreciable higher ionization capacity, while the μ- and π- mesons having the same range have a normal ionization capacity. This makes it possible to determine the mass of these particles from impulse and range and independently from the impulse and ionization capacity.

The brief review of our work presented herein shows that the basic conclusion relative to the existence of new particles, which we had arrived at in the course of earlier work, has been justified by more recent investigations even though in the course of investigations and adaptation of the method we had made a number of mistakes and incorrect deductions. In addition to the presently known particles with a mass of 300 me, (π - meson) communications are being continuously received from different authors who observe particles heavier than the π- meson.

In conclusion I would like to point out that as a result of the work on analysis of the mass of cosmic radiation particles we have evolved a new experimental procedure which permits highly accurate measurement of impulses and masses of charged particles. This procedure which possesses a number of incontestable advantages over other methods, especially insofar as mass analysis of cosmic radiation particles is concerned, is gradually gaining recognition. Recently an instrument similar to ours, but considerably inferior to it in accuracy of impulse measurements and reliability of the trajectories, has been constructed by a group of physicists under the leadership of Blackett. It is beyond doubt that this procedure will make it possible to solve a number of other current problems concerning the nature of cosmic radiation.

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BIBLIOGRAPHY

[1] A. Alikhanyan, A. Alikhanov and A. Vaisenberg, Journ. of Phys. 11, 97, 199, 1947.

[2] A. Alikhanyan, A. Alikhanov and A. Vaisenberg, ZhETF [Zhurnal Eksperimental'noy; Teoreticheskoy Fiziki] 18, 301, 1948.

[3] A. Alikhanyan, A. Alikhanov, V. Morozov, G. Muskhelishvili and A. Khrimyan, DAN SSSR [Doklady Akademii Nauk SSSR] 58, 1321, 1947.

[4] A. Alikhanyan, A. Alikhanov, V. Morozov, G. Muskhelishvili and A. Khrimyan, ZhETF, 18, 673, 1948.

[5] A. Alikhanyan, V. Morozov, A. Khrinyan, G. Muskhelishvili and ZhETF 19, 953, 1949.

[5a] I. Pomeranchuk, ZhETF, 18, 759, 1948.

[6] A. Alikhanyan and A. Alikhanov, ZhETF, present issue, page 1023.

[7] A. Alikhanyan, D. Samoilovid, I. Guzevich, Kh. Babayan, R. Gerasimova. Zh. ETF 19, 664, 1949. A. Alikhanyan, D. Samoilovich, I. Gurevich, Kh. Babayan, ZhETF 19, 667, 1949.

[8] C. Franzinett, Phil., Mag., 41, 86, 1950.

[9]. P. E. Hodyson. Phil., Mag., 41, 725, 1950.

[10] M. Renardier, H. Moucharafien, M. Morand, C.R., 231, 848, 1950

[11] N. Wagner a D. Copper Phys. Rev., 76, 449, 1949.

[12] S. Azimov, N. Birger, N. Dobroton, G. Zhadanov, Yu. Kokurin and S. Slavatinskiy, DAN SSSR 78, 447, 1951.

[13] U. Camerini, P. H. Fowler, W. O. Lock, H. Muirhead, Phil. Mag. 41, 413, 1950.

[14] H. S. Bridge a. M. A. Annis. Phys. Rev. 82, 445, 1951.

[15] C. C. Butler, W. G. V. Rosser a. K. H. Barker, Proc. Roy. Soc. A., 63, II, No. 362 A. 1950.

[16] N. Dobrotin, Journ. of Phys. 10, 207, 1946.

[17] N. Dobrotin, Ya. Graevskaya, N. Grigorov, S. Nikol'skiy and I. Rappoport, DAN SSSR 77, 599, 1951.

SECTION 11

NORMS AND ESTIMATES OF FUEL AND LUBRICANT CONSUMPTION

The quantity of fuel in kilograms per unit measure of work constitutes the specific norm of fuel consumption. One thousandth of the stated ton/kilometers of hauled cargo, the horsepower/hour and the ship/hour are adopted as the unit measure of work, for river transport.

The standardization of fuel consumption has as its goal the control of its efficient utilization, the estimate of fuel required for the river fleet as a whole, and the promotion of an economy drive, while making sure that the projected production goal is achieved with the highest possible technical efficiency.

Two categories are established for the norm of specific fuel consumption: one for transport, designed to control the proper utilization of the fuel in the achievement of the transport task, and another for technical performance, for the purpose of controlling the proper fuel consumption in the ship's power plant. The transport norms are fixed by the Ministry of the River Fleet USSR, for each navigation line, while the technical performance standards are worked out by the maintenance departments of the lines.

The specific fuel consumption transport standards are established for an ideal fuel (7000 calories per kilogram), with standard grade fuel as the basis of the estimate. The conversion of the ideal to the natural fuel is made according to caloric equivalents, established by the MRF. The technical performance standards of fuel consumption are worked out for 1 horsepower/hour and are also calculated for a ship/hour for each month of navigation, according to natural standard grade fuel.

The transport standards for the specific fuel consumption are established for the navigation lines as a whole:

(a.) For transport work performed by the freight and freight-passenger fleet in kilograms of ideal fuel for one thousandth of given ton/kilometers.

(b.) For the transport carried out by the towing fleet, with fuel consumption figures for the roadsted and auxiliary hauling fleet in kilograms of ideal fuel for one thousandth of given ton/kilometers.

The given work of the mixed freighter and passenger fleet is computed as the sum of ton/kilometers of work, multiplied by 0.1 (the overall weight of a passenger is calculated at 0.1 ton).

The technical performance standards of consumption are calculated per ship on the basis of the ship/hour,:

A. For freighters and freight-passenger ships:

   (a.) per hour of work en route.

   (b.) per hour of work when berthed (under steam)

B. For towing, transport, roadsted and auxiliary maintenance vessels.

   (a.) per hour of travel with barges and upstream with rafts.

   (b.) per hour of travel with rafts downstream.

   (c.) per hour of travel without load.

(d.) per hour of work when berthed (under steam).

(e.) per hour of roadsted manoeuvering.

(f.) per hour of work of the transfer pump.

The fuel consumption for firing the boilers and getting up steam, as well as cooking (camboose) for the crew and passengers, in every branch of the fleet, is included in the basic norms of fuel consumption.

The technical performance standards are worked out with reference to the type of power plant and its output, predicated on statistical data and on the results of technical tests aboard the motorships. As a rule, the established norms of fuel consumption are revised every year before the navigation season, taking into consideration such factors as redesign and modernization introduced aboard ship, as well as the experience of the various units and the statistical data of the last navigation period. The natural (crude) fuel consumption norms are drafted for each separate vessel and these are approved by the chief of the navigation line. They are issued in the form of an order for the navigation line and are brought to the attention of the managing personnel of the vessels.

TABLE 12

Types of Engines	Specific Fuel Consumption for the year per 1 horsepower/hour.
Non compressor, four stroke engine	165 - 210
Non compressor, two stroke engine	150 - 220
Compressor type, four stroke engine	190 - 230
Compressor type, two stroke engine	185 - 230
Automobile type, gasoline engine	250 - 300
Tractor type, petroleum engine	280 - 330
Engines with ignition chamber	280 - 350

The working standards of lubricant consumption are prepared separately for each vessel on the basis of factual data concerning consumption and on the basis of special tests.

Table 13 furnishes the basic parameters of marine non-compressor Diesels of domestic manufacture as well as the fuel and lubricant consumption norms furnished by the manufacturing concerns based on work at full load. Table 12 lists the fluctuating range of specific fuel consumption for different types of Diesels.

TABLE 13

No.	N_e	z	D	S	n	ε	c_e	g_e
1	15	1	160	200	650	15.5	220+10%	15+10%
2	30	2	160	200	650	15.5	220+10%	15+10%
3	50	2	160	270	550	17-18	215	9
4	50	2	200	300	430	18	205	18
5	105	3	190	320	430	17-18	215	9
6	140	4	190	320	430	17-18	215	9
7	210	6	190	320	430	17-18	195+10%	9
8	1500	6	540	900	130	12	180+5%	3
9	2000	8	430	610	250	13.5	180+5%	2.2+7.5
10	320-370	6	290	430	300-350	13	180+5%	3
11	400	6	345	500	240	13	185+5%	5.5
12	600	6	425	600	187	13	185+5%	5.5
13	900	6	480	700	187	13	180+5%	2.5
14	80	4	130	180	1500	19-20	230	15
15	200	6	165	210	1300	15	190	10
16	150	6	150	180	1500	14-15	205	14

Following are the connotations of the symbols in Table 13:

N_e - effective output of the engine in horsepower/hours.

z - number of cylinders.

D - cylinder diameter in millimeters.

S - piston stroke in millimeters.

n - revolutions per minute

ε - degree of compression

c_e - guaranteed fuel consumption in grams per effective horsepower/hour.

g_e - guaranteed oil consumption in grams per effective horsepower/hour.

The engines under numbers 1-9 are two stroke, those under 10-16 four stroke.

The consumption of firewood in marine gas plants with tractor engines is at the rate of 1 to 1.3 kilograms per effective horsepower/ hour, depending on the grade and the moisture content of the fuel. In marine gas plants which work on anthracite, the fuel consumption for gas engines is at the rate of 320 to 350 gallons per effective horsepower/hour. In those cases where the engine works on the liquid gas cycle, anthracite consumption is at the rate of 240 to 280 gallons per effective horsepower/hour, while that of liquid fuel is at the rate of 7 to 10 gallons per effective horsepower/hour.

The specific fuel consumption c_i in grams per actual horsepower/hour can be ascertained according to the equation

$$c_i = \eta_m c_e$$

where η_m is the mechanical "k p d".

the lubricating oil consumption depends on the type of engine employed, its power, design, lubricating system and on its mechanical condition. Generally oil consumption per effective horsepower/hour assuming the condition of the engine to be satisfactory, fluctuates within the following limits: where the engine capacity is up to 10 horsepowers, the rate of oil consumption is 10 to 20 grams for 10 to 50 horsepowers it is 8 to 15 grams for 50 to 200 horsepowers it is 5 to 10 grams for 200 to 1000 horsepowers, it is 3 to 6 grams, and upward to 1,000 horsepowers, the rate of consumption is 2 to 3 grams.